

**Release of *Sasajiscymnus tsugae*, *Scymnus sinuanodulus* (Coleoptera: Coccinellidae)
and *Laricobius nigrinus* (Coleoptera: Derodontidae)
On the Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae) in NJ**

Annual Report 2011

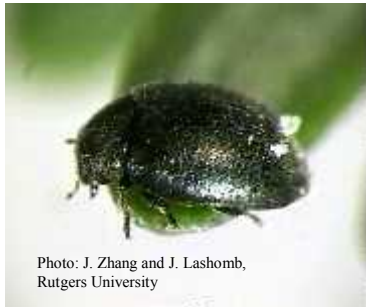


Photo: J. Zhang and J. Lashomb,
Rutgers University

Sasajiscymnus tsugae



Scymnus sinuanodulus (female)



Photo: Ashley
Lamb, VPI

Laricobius nigrinus

Prepared by:

**Mark Mayer
Jennifer DeSio
Thomas Dorsey**



**Division of Plant Industry
Phillip Alampi Beneficial Insect Laboratory
Trenton, NJ 08625**

ACKNOWLEDGEMENTS

The following individuals contributed greatly to the project and we thank them for all their help

New Jersey Department of Environmental Protection, Division of Parks and Forestry

John Keator, Superintendent,
High Point State Park
Paul Stern, Superintendent,
Stokes State Forest
Blanca Chevrestt, Superintendent,
Swartswood State Park
Ernie Kabert, Superintendent,
Worthington State Forest
Jessica Krugel, Superintendent,
Wawayanda State Park

Connecticut Agricultural Experiment Station

Dr. Carole Cheah

New Jersey Department of Agriculture Phillip Alampi Beneficial Insect Laboratory

Nicholas Wilson
Jennifer DeSio

Pennsylvania Department of Conservation and Natural Resources

Brad Regester
Don Egan
Houping Liu

USDA-Forest Service

Bradley Onken
Dr. Michael Montgomery
Dr. Rusty Rhea
Dr. Richard Reardon

United States Department of Interior - Delaware Water Gap NRA

Richard Evans
Jeffrey Shreiner

Virginia Polytechnic Institute and State University

Dr. Scott Salom
Dr. Ashley Lamb
Carrie Jubb

Symbiont Biological Pest Management

Dr. Richard McDonald

ABSTRACT

Since 1998, a total of 288,675 *Sasajiscymnus tsugae* have been released into 64 New Jersey hemlock sites. Overwintering recoveries of *S. tsugae* have been made at 12 different sites since 1999. Recovery of *S. tsugae* on stressed trees was difficult due to branch dieback caused by the HWA and poor tree health, which reduced the amount of new growth that the HWA feeds on. No *S. tsugae* were recovered in 2011. A total of 10,355 *Scymnus sinuanodulus* have been released in NJ in nine sites but there have been no recoveries. 51 overwintering *Laricobius nigrinus* beetles were recovered from six of the ten pre-2010 release sites in October; one recovery was from the 2005 release site in Worthington SF which is seven consecutive years of recoveries for that site. A total of 30 *L. nigrinus* were released in New Jersey in 2011 bringing the total number of beetles released by the New Jersey Department of Agriculture to 10,567. In 2011 a grand total of 155 larvae and nine adult *L. nigrinus* were recovered in the spring with an additional 8 adults collected in fall 2011. This represents not only the largest single yearly total of hemlock woolly adelgid predators that have ever been recovered in NJ in one season but also is greater than all previous seasons combined.

INTRODUCTION

In the spring of 1997, under a cooperative agreement with the United States Forest Service (USFS), the New Jersey Department of Agriculture's (NJDA) Phillip Alampi Beneficial Insect Laboratory (PABIL) received 100 *Sasajiscymnus tsugae* (Coleoptera: Coccinellidae) from Dr. Mark McClure and Dr. Carole Cheah of the Connecticut Agricultural Experiment Station (CAES) to serve as a back up to their colony. One of the goals of the PABIL was to try to further develop and refine the rearing procedures for *S. tsugae*. Beginning in 1998 and continuing through 2006, a total of 288,675 *S. tsugae* has been released into NJ hemlock stands.

In 2004, the Laboratory undertook a new program rearing a Chinese ladybeetle, *Scymnus sinuanodulus* (Coleoptera: Coccinellidae), in conjunction with the US Forest Service and Dr. Carole Cheah of the CAES. The goal was to develop a mass rearing procedure for the new species and then release the species after sufficient numbers have been produced. A total of 10,355 *S. sinuanodulus* has been released in New Jersey among nine sites through 2007.

In 2005, Virginia Polytechnic Institute and State University (VPI) shipped 300 *Laricobius nigrinus* to the PABIL for release in northern New Jersey. VPI shipped an additional 3,300 beetles to New Jersey during 2007-2009, and 4,000 in 2010. The lab also received 1,119 field collected beetles from 2007-2009 as well as 1,743 in 2010 collected by Dr. Richard McDonald from Seattle, WA. A total of 10,567 *L. nigrinus* have been released in New Jersey distributed among ten hemlock stands.

OVERVIEW

Hemlock Woolly Adelgid (HWA) is a common, but insignificant insect on ornamental and forest hemlock and spruce in Japan and China. It does not attain high densities on hemlock in Asia except for trees growing on very poor sites. There is no significant injury to the Asian hemlocks most probably due to host resistance and the presence of native predators such as *S. tsugae*, *Scymnus spp.* and *Laricobius spp.* that regulate HWA populations.

The first infestation in the eastern US was discovered on the east coast in Virginia in the 1950's. This infestation is believed to be an accidental introduction from Japan. Eastern hemlocks are the successional climax trees in Northern NJ forests and although hemlock is not a valuable timber tree, the wood is used for barns, sheds, pulpwood, and landscaping and it is ecologically important providing cover for deer, turkey, ruffed grouse, and others. About 90 species of birds use hemlock as a nesting site, roost site or winter shelter. Northern goshawk, solitary vireo, and the black-throated warbler require habitats provided by a hemlock forest and would be stressed should the hemlock stands be reduced for any reason.

(Hennessey 1995). Hemlock is also an important component of some of the more popular recreational areas in NJ, due to the dense canopy, cooler temperatures in summer, which provide a much-needed respite from the heat for those who visit the stands. The species is also an important component of the large watersheds in Northern NJ.

In NJ, all of the hemlock stands have had some level of HWA infestation. The healthiest stands were in northern Passaic and Sussex Counties, but the majority of stands are stressed and many will not remain healthy unless a biological control effort is undertaken. In the NJDA Permanent Study Plots, the long-term mortality as of 2010 due to the HWA averages 60.7%.

HWA populations are virtually unmanageable in hemlock forests using traditional control measures. Application of chemical insecticides is impractical due to the inaccessibility of most stands, proximity to water, poor coverage of aerial spraying and/or excessive cost.

BIOLOGICAL CONTROL

In 1992, Dr. Mark McClure of the CAES initiated a trip to Japan to attempt to find and collect potential HWA predators. He collected a Coccinellid, *S. tsugae*, which showed promise and the USDA granted a permit for its release in 1995. Dr. Mike Montgomery of the USDA-FS has worked with *Scymnus* spp. from China and Dr. Scott Salom of Virginia Tech is working with a native Derodontid beetle, *Laricobius nigrinus* and a Japanese *Laricobius* sp. Recently, the USFS has sponsored searches in China and Japan for some additional predators, some of which are in quarantine in the US. *L. nigrinus* is also being collected in the Pacific Northwest by Dr. Richard McDonald of Symbiont Biological Pest Management.

MATERIALS AND METHODS

All *S. tsugae*, *S. sinuanodulus* and *L. nigrinus* release sites were monitored using the VPI monitoring protocols (Mausel et. al. 2007).

Monitoring for the presence of the beneficial ladybeetles was conducted at each site from the spring through late fall if sufficient hemlock woolly adelgid populations were present. If the stand at the site was in poor health or if the HWA population was low, the site was not surveyed. Surveys were conducted at 21/64 of the release sites for *S. tsugae*, all nine of the *S. sinuanodulus* release sites and in October at all nine *L. nigrinus* release sites within the state. Each site was surveyed for 2.0 people hours or until a beetle was found. The original sampling methodology consisted of a one meter square beating sheet was placed beneath several branches and the branches were struck ten times with a plastic whiffle ball bat (Figure 1). Any life stages of the beetles recovered on the beating sheet were recorded.

Figure 1. *Sasajiscymnus tsugae* Sampling and Recovery



Photo by L. Bronhard

In 2011, a change was made in the monitoring methodology after a training session with Dr. Richard McDonald of Symbiont Pest Management. Previously, staff had used one meter square beating sheets as

described above and had tapped the branches down over the beating sheets. Dr. McDonald's methodology was subtly different in that he used an upside down umbrella and gently tapped up on the branches and then down to recover *L. nigrinus* adults and larvae. Also, only the sunny sides of the trees that had hemlock woolly adelgid populations were sampled resulting in the recovery of more *L. nigrinus* beetles and larvae. The *L. nigrinus* larvae are gray but are often covered with hemlock woolly adelgid wool and were much easier to see on the contrasting color umbrellas than on the white beating sheets. The umbrellas are more convenient to use in the forest as they are more easily transportable as well as being less susceptible to winds than the beating sheets.

When *S. tsugae* and *S. sinuanodulus* beetles were in production by the Phillip Alampi Beneficial Insect Laboratory they were transported to the new release sites in either Sweetheart[®], 165 oz., stock number 10T1 paper buckets covered with Sweetheart[®] 10V19S paper lids or Sweetheart[®] Flexstyle 10 oz. food cups fitted with nylon screen at the ends. There were 2,500-5,000 beetles per bucket and up to 500 beetles per cup. The cups and the buckets are filled with excelsior for increased surface area. At the release site the lid is removed and the containers and lids are placed into the branches of the tree. After five minutes, any stragglers in the buckets are gently brushed out onto the infested branches using a soft, 1-inch paintbrush. The release trees were at least moderately infested with HWA.

L. nigrinus was shipped to PABIL in plastic vials from VPI, 50 beetles per vial and were released following the protocol in Mausel, *et. al* 2007. The PABIL also received field-collected *L. nigrinus* in the Fall from Dr. Dick McDonald who collected wild *L. nigrinus* in Seattle.

RESULTS AND DISCUSSION

The PABIL released the coccinellid predators *S. tsugae* from 1998 through 2006 and *S. sinuanodulus* from 2005 through 2007. The PABIL received a new predator, *L. nigrinus*, in January 2007 so all rearing efforts have been directed toward the new species with the Coccinellids dropped from the laboratory cultures. *S. tsugae* is established in New Jersey and it is no longer necessary to rear in the laboratory. Surveys will continue for *S. sinuanodulus*. Table 1 summarizes the releases and recoveries of all three predators 1997 through 2011. More than one release can be placed into a site. With *Laricobius*, if the releases were in the same hemlock stand, then the stand was considered one release site.

There are no heavily infested hemlock stands with sufficiently healthy trees in New Jersey that are suitable for collecting sufficient rearing material. Pennsylvania Department of Conservation and Natural Resources collect infested hemlock and sent to the PABIL to rear the beneficials. Recovering overwintering beetles to prove establishment has been a tedious and challenging process. No *S. tsugae* and no *S. sinuanodulus* were recovered in NJ in 2011, although *L. nigrinus* was recovered from four sites using Dr. McDonald's methodology.

Figure 2 is a map of the predator release sites in the state. There are several factors that account for the low recovery rates of *S. tsugae*: First, HWA populations have been relatively low throughout New Jersey. In 1999 and 2000, the last years of high hemlock woolly adelgid populations in New Jersey, was when the most *S. tsugae* beetles were recovered. Not surprisingly, the recovery of *S. tsugae* would seem to be dependent on the amount of host material. Second, collecting becomes more difficult due to branch dieback of the lower limbs; it becomes increasingly more difficult to find branches that could be sampled using the beating sheet technique. In New Jersey, the average crown ratio for the hemlock forest is 26% (Figure 6), but crown ratios of 85-100% are needed to sample for the predators. Lastly, the *S. tsugae* beetles may have dispersed to the higher branches, (Scudder, *et. al* 2001, Cheah *et. al* 2005) which are unreachable by the survey personnel. Dr. Jerome Grant at the meeting of the Hemlock Woolly Adelgid Biological Control Committee at the 21st USDA Interagency Research Forum on Invasive Species (personal communication) is recovering *S. tsugae* from older sites and stated that it may take longer than

we expect to get high recoveries of that species.

Table 1. *S. tsugae*, *S. sinuanodulus* and *L. nigrinus* Releases in NJ 1997 - 2009

Year	No. <i>S. tsugae</i> Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries	No. <i>S. sinuanodulus</i> Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries	No. <i>L. nigrinus</i> Released in New Jersey	No. of Release Sites	No. of Sites with Recoveries
1997*	0	0		-	-		-	-	
1998	75,500	15		-	-		-	-	
1999	65,000	13	6	-	-		-	-	
2000	50,000	13	3	-	-		-	-	
2001	30,500	6	2	-	-		-	-	
2002	40,260	9	2	-	-		-	-	
2003	17,500 ¹	5	1	-	-		-	-	
2004	15,000 ¹	2	1	-	-		-	-	
2005	230	1	1	1,530	3	0	300	1	
2006	2,185	1	1	1,500	2	0	-	-	1
2007	0	0	1	6,305	4	0	1,390	3	2
2008	0	0	1	0	0	0	2,033	4 ³	3
2009	0	0	0	0	0	0	1,071	2	2
2010	0	0	0	0	0	0	5,743	2	6
2011	0	0	0	0	0	0	30	1	4
Totals	288,675	64²	12	10,335	9	0	10,537	12	7

*From a starter colony of 100 adult beetles received in May 1997

¹ includes 2,500 egg release

² This is the number of new sites, not the number of releases; some sites received more than one release in the same year or in an adjacent area nearby

³ Two of the sites were new and two were augmentative releases

Figure 2 also shows the release and recovery sites for *S. tsugae* over the course of the project. The majority of the recoveries are in certain areas, notably the Kittatinny Ridge in the Northwest part of the state where the hemlock stands are still healthy. The fact that so few have been recovered is disappointing. We did not expect much, if any, impact on the HWA population as yet because the number of beetles that were recovered was minimal. All introduced populations go through a lag phase in their establishment where there are too few of the new species around and it takes some time for them to enter the log phase of their population curve.

Figure 3 illustrates the HWA sistens population and the number of *S. tsugae* recovery sites by year up through 2010 when the Permanent Study Plots were dropped. The most *S. tsugae* recoveries were made in 1999 which was also the year that the highest HWA population levels were observed. The beetles may not show up until the HWA population increases, although the HWA population did increase in 2008 but there was no subsequent recovery of *S. tsugae*. That may have been due to a lack of survey personnel due to retirements and budget cuts. This increase of the HWA population in 2008 was thought to improve the chances of recovering more *S. tsugae* in succeeding years but no recoveries have been made. There were no summer staff personnel in 2011 which may be part of the reason that the number of recoveries was zero. The majority of the recoveries were along the Kittatinny Ridge in the Skylands section of NJ.

Figure 2. Hemlock Stands and Beneficial Insect Release/Recovery Sites in New Jersey.

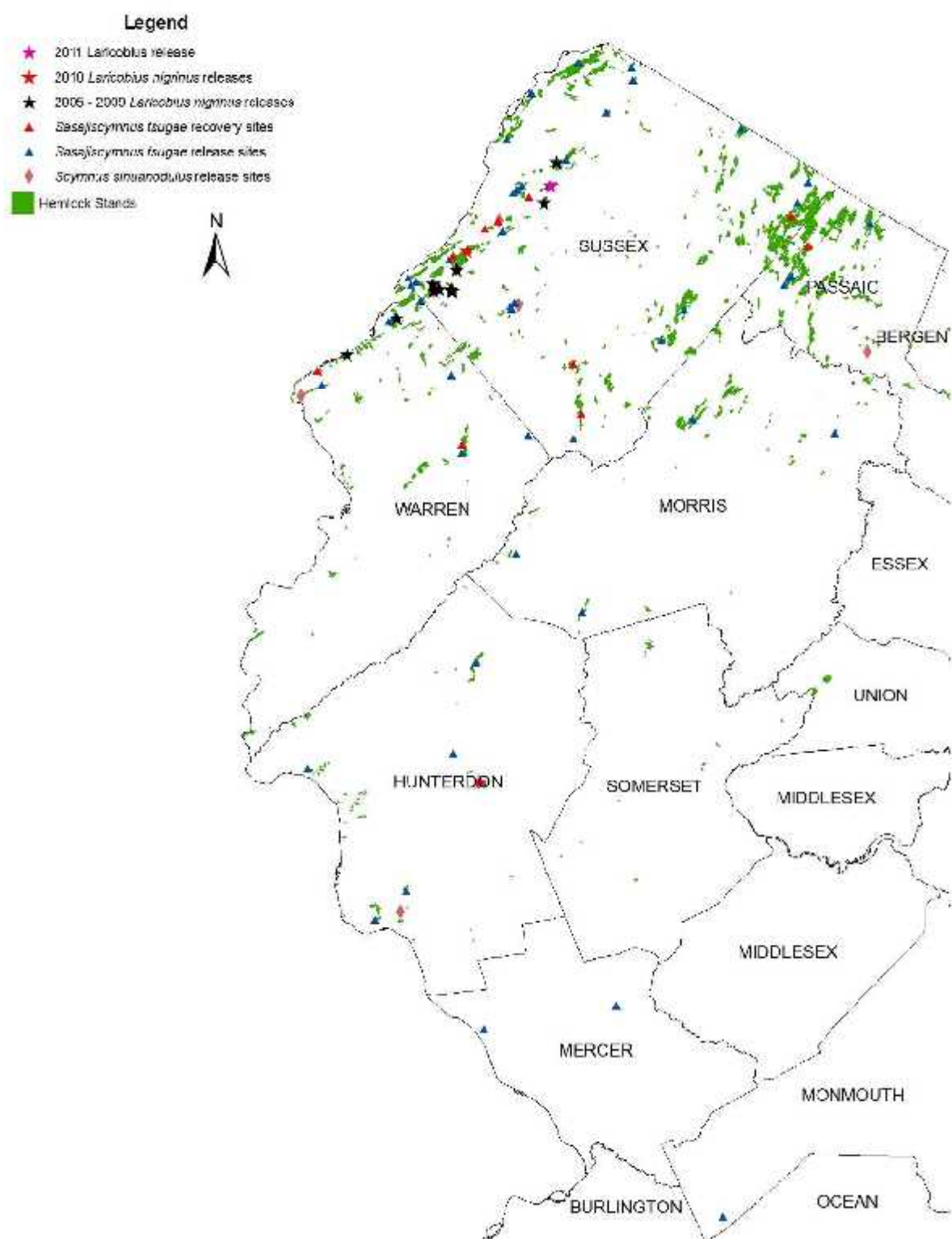
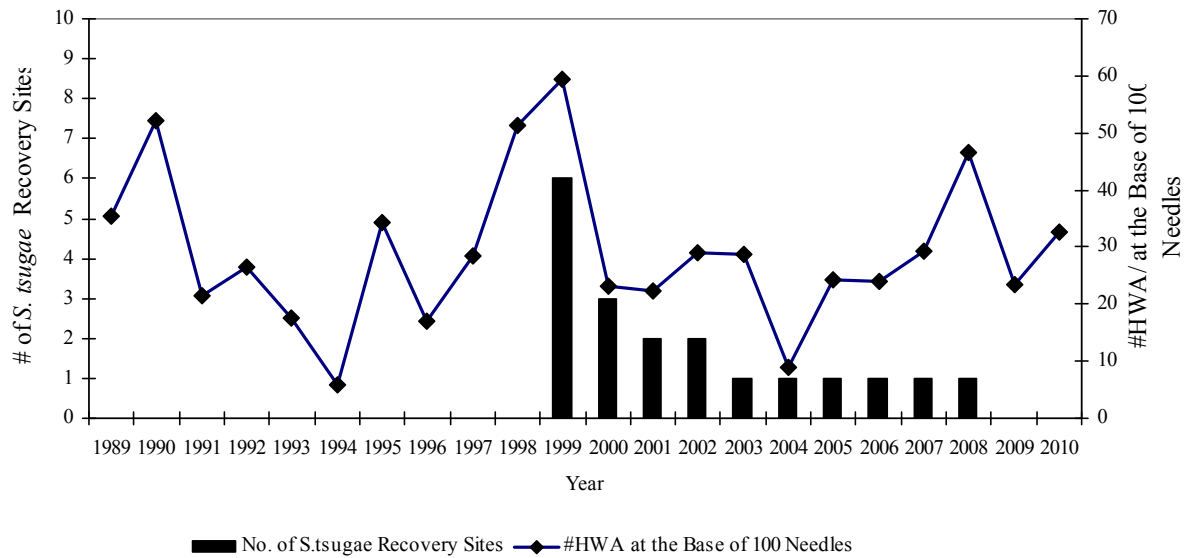
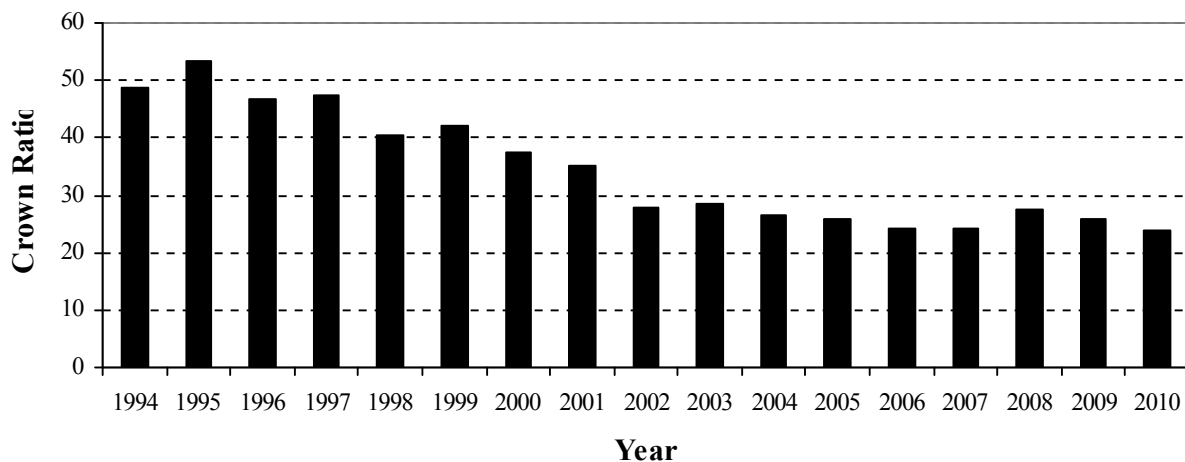


Figure 3. HWA Sistens Population and *S. tsugae* Recovery Sites in NJ 1989-2010



Cheah et. al. 2005, found that the trees in the Skylands were healthier overall than the trees in the Highlands region of New Jersey, most likely because they were infested later. The temperatures in the Skylands are also slightly colder due to the higher elevations which could result in higher hemlock woolly adelgid mortality. Releasing 10,000 beetles into the middle of a forest sounds like a large quantity, however, when one considers the number of trees, the number of beetles released would be hard pressed to even have an impact on an individual tree.

Figure 4
Average Crown Ratio of Hemlock Trees in NJ 1994-2010



S. tsugae

After they have been released on a tree, *S. tsugae* tends to disperse upwards towards the canopy. As previously mentioned Drs. Carole Cheah and Mark McClure have established that the beetles overwinter on the tree and are of the opinion that the beetles are higher up in the canopy in the years following release (Personal Communication). Cheah et. al. 2005 presented data from New Jersey that showed that the beetles do move up into the trees and disperse outwards from there. Hodek (1973) has reported that coccinellids readily disperse and this may be true of *S. tsugae*. This may be one of the reasons why beetle recovery rates have been lower than expected for the number of beetles released. Observations in the laboratory corroborate field observations as the beetles move up to the top of the cages as the day progresses (D. Palmer, NJDA, personal communication). In Figure 4, the average crown ratio has declined from almost 25% from 1994 to 2010 making it difficult to find trees to sample for the beetles. There has also been a decrease in personnel the past three years due to budget cutbacks giving field staff less man hours to survey for the beetles. Therefore, when ground surveys yield poor results, it does not mean that the *S. tsugae* beetles are not present, but that they may be in the upper canopy where they cannot be sampled by ground crews. Additionally, in August when the HWA aestivates, it becomes difficult to find the beetles as they move elsewhere to locate food.

Scymnus sinuanodulus

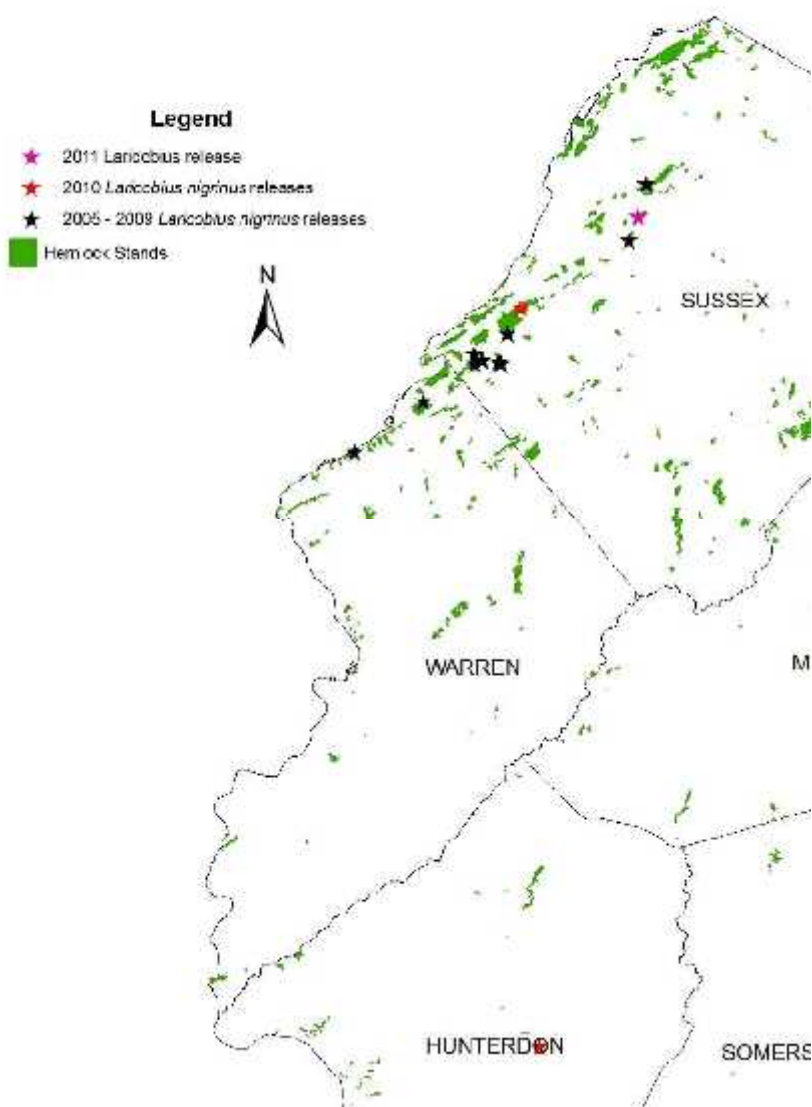
In 2005 *S. sinuanodulus* was released for the first time in New Jersey at three sites and into two additional sites in 2006. The beetles were readily found at the 2006 release sites until the middle of summer during the same season but disappeared after consuming all of the hemlock woolly adelgid. Only 10,355 *S. sinuanodulus* have been released in NJ. No overwintering beetles were recovered but based on previous field observations it appears to be too soon to determine whether the insects have established. Dr. Mike Montgomery (personal communication) of the USFS is of the opinion that the beetles may be a better ecological fit to the Southern Appalachians where they have been recovered so *S. sinuanodulus* may not overwinter in NJ. That remains to be determined.

Laricobius nigrinus

L. nigrinus is a Derodontid beetle native to the Pacific Northwest that is predacious on the hemlock woolly adelgid. The beetles are active from fall until spring whenever the temperatures exceed 0° C. The beetles, from a colony at Virginia Tech, were released for the first time in 2005 in Worthington State Forest and recoveries were made in 2006, 2007, 2008, 2009 and 2010 from separate release trees. A total of 5,743 *L. nigrinus* were released in New Jersey in 2010 distributed among four sites bringing the total number of released beetles to 10,537. The vast majority of the beetles were released above Buttermilk Falls in the Delaware Water Gap NRA with the idea being that the *L. nigrinus* will have a greater chance of population increase in an area where they are concentrated. Nearby release sites are approximately 2.5 to 5.5 km away giving the beetles a greater chance to find each other and reproduce. Staff from the National Park Service has also released 3,147 *L. nigrinus* from 2007-2009 in the Upper Van Campens Watershed and in the Camp Ken-etiwa-pec/Skyline Drive area (circled area in Figure 7, Richard Evans and Jeff Shreiner, personal communication). Beetles were recovered in October 2008 from seven of the ten previous release sites. The sites where there were no recoveries had low to zero populations of the HWA. A total of 51 adult beetles were recovered in the Fall of 2010 with recoveries at Worthington SF made 30m from the closest release tree. That was extremely encouraging. In 2011 a grand total of 155 larvae and nine adult *L. nigrinus* were recovered in the spring with an additional 8 adults collected in the Fall. This represents not only the largest single

yearly total of hemlock woolly adelgid predators that have ever been recovered in NJ in one season but also is greater than all previous seasons combined. Dr. McDonald also stated that that he believes that we are “locked on” and if the NJ sites follow the same progression as the sites in NC, we should see improvements in tree health in the next few years. Within NJ in 2011 we have confirmed dispersal of *L. nigrinus* of up to 650 meters and they have probably gone further than that. The *L. nigrinus* recoveries are very encouraging considering the small quantity of beetles released. Biological controls generally take many years before their populations increase to the point where they are effective. There are no other cost effective controls available to protect natural hemlock stands at this time other than biological control.

Figure 6. Release Sites for *L. nigrinus*



2012 Plans

In 2012, the PABIL intends to continue to survey for HWA predators in areas where there are hemlock woolly adelgid populations and also to release (*L. nigrinus*) in the northwestern corner of the state as they become available. The goal is to release as many beetles as can be provided in high value public forested areas in northern NJ in an attempt to boost their chances of establishment.

The releases will be made according to a priority list as follows:

1. State and Federal lands, with a minimum of a moderate hemlock woolly adelgid population, including natural lands that are located in areas in close proximity to other hemlock stands where the beetles can redistribute themselves.
2. County and municipal lands with a moderate hemlock woolly adelgid population located in areas in close proximity to other stands where the beetles can redistribute themselves readily.
3. Private lands with a moderate hemlock woolly adelgid population hemlock stands (excluding landscapes).

CONCLUSION

The *S. tsugae* program has been successful in that the beetles have become established in the state as evidenced by the recoveries of adults and/or larvae at 12 of 64 sites. It is probable that *S. tsugae* is established at more sites, but the dieback of the lower branches in many sites and lack of personnel limits our field search and survey capabilities. Also, the dispersal behavior of the beetles to move up into the canopy of the tree into the healthy foliage following release makes recovery of the beetles difficult. The *S. tsugae* population is still present and their actual impact may not be fully known for some years. The Chinese ladybeetle *S. sinuanodulus* has been released but not recovered. *L. nigrinus* has been released, has established, and is increasing in population in NJ with the highest number of beetles ever recovered in 2011.

REFERENCES

- Cheah, C., M. Mayer, D. Palmer, T. Scudder, and R. Chianese. 2005.** Assessments of biological control of hemlock woolly adelgid with *Sasajiscymnus* (*Pseudoscyrmnus*) *tsugae* in Connecticut and New Jersey in Onken, B. and R. Reardon Third Symposium on hemlock Woolly Adelgid in the Eastern United States. Asheville, North Carolina, February 1-3, 2005. http://na.fs.fed.us/fhp/hwa/pub/2005_proceedings/cheah.pdf
- Evans, R. 2005.** Ecologist, Delaware Water Gap National Recreation Area.
- Hennessey, R. 1995.** Field Release of a Nonindigenous Lady Beetle, *Pseudoscyrmnus* sp. (Coleoptera: Coccinellidae), for Biological Control of Hemlock Woolly Adelgid, *Adelges tsugae* (Homoptera: Adelgidae). Environmental Assessment. USDA-APHIS Riverdale, MD.
- Hodek, I. 1973.** Biology of Coccinellidae. Dr. W. Junk N.V., The Hague.
- Mausel, David L. , Theresa A. Dellinger, Ashley B. Lamb, Scott M. Salom, and Loke T. Kok. 2007.** Field Instructions for Release of *Laricobius nigrinus*, a Biological Control Agent for the Hemlock Woolly Adelgid in the Eastern U.S. Department of Entomology, Virginia Tech, Blacksburg, VA.
- Mayer, M. and D.C. Allen. 1983.** *Chilocorus stigma* (Coleoptera: Coccinellidae) and Other Predators of Beech Scale in Central New York. In, Proceedings, IUFRO Beech Bark Disease Working Party Conference, USDA-FS General Technical Report WO-37: 89-98.
- Mayer, M., T. Scudder, C. Burdel, F. Golz, and T. Dorsey. 2007.** Unpublished Annual Report. The Effect of the Hemlock Woolly Adelgid *Adelges tsugae* (Homoptera: Adelgidae) in New Jersey Hemlock Stands. Phillip Alampi Beneficial Insect Laboratory, Division of Plant Industry, New Jersey Department of Agriculture. <http://www.state.nj.us/agriculture/plant/biolab.htm>
- Millers, I., R. Anderson., W. Burkman, W. Hoffard. 1992.** Crown Condition Rating Guide. USDA-FS Technical Report.